Using technology and techniques from outside the space industry to overcome engineering challenges posed by planetary protection and ultra-clean requirements on flight hardware

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Planetary Protection (PP) is the minimisation of biological cross-contamination between Earth and other planets and is imposed for legal (COSPAR) as well as technical reasons. To meet Planetary Protection requirements constraints are imposed on all phases of the mission, from design and manufacture to operations and disposal. In many cases the technologies required to meet Planetary Protection (and cleanliness) requirements must be drawn from outside main stream space technology procurements and may require different approaches to assembly and testing of the spacecraft.

The main areas identified where novel approaches to address Planetary Protection are needed include; the sterilisation of spacecraft and/or components, 'aseptic assembly' techniques to maintain sterility during integration and contamination control within clean areas & also during spacecraft venting (both on ascent and descent). Relevant technologies may be spun in from a range of industries where aseptic assembly or 'ultra-clean' levels of cleanliness are required. These include the medical, food processing, pharmaceutical and semi-conductor industries.

Currently the only fully qualified method of reducing bioburden for flight hardware is by Dry Heat Microbial Reduction (DHMR). This is the method that was used to sterilise fully assembled Viking landers, and has been used for components on the MER, MPF and Beagle2 missions. Work is ongoing on the assessment of low temperature approaches to sterilisation, such as Hydrogen Peroxide (Steris® and Bioquell®) and Chlorine Dioxide to determine efficacy and compatibility with a wide range of spacecraft materials. Additionally MGSE & EGSE must also be suitable for sterilisation and to reduce contamination further reduced levels of equipment and personnel within the cleanroom, utilising novel technological approaches such as wireless communication.

Materials normally used for medical packaging, such as Dupont™ Tyvek® can be used to pack GSE and flight hardware during MAIV. During the MAIV of flight hardware, considerations of packing and storage need to be made and techniques used to preserve specimens in museums are currently being investigated for suitability for flight hardware.

High Efficiency Particulate Air (HEPA) filters are used in the cleanroom to filter out biological particles, but these may also need to be qualified for venting enclosed volumes such as electronic boxes during Earth ascent and Mars descent. High temperatures that may be experienced during descent module Mars descent will present a particular problem for HEPA filter design.

Approaches normally used for semi-conductor and pharmaceutical production provide technologies and procedures to achieve 'ultra-clean' levels of cleanliness on flight hardware. This is needed for missions such as Exomars in the search for organic traces of past or present life on Mars. It is essential that all organic contamination of the sample pathway is removed and that removal is verified. This will require the preparation and maintenance of ultra-clean flight hardware, an approach which has not been achieved on any previous missions.

It is concluded that the problems of both Planetary Protection and ultra-clean flight hardware can be overcome by the use of existing technologies spun in from other domains. However the use of these technologies will require investigation as to their suitability to flight hardware, as well as modification to the normal approach to spacecraft MAIV, the scale of which must not be under-estimated.